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Concept understanding and mathematical representation ability: DMR model with a reciprocal teaching approach

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Abstract:
Students must get a thorough comprehension of mathematical concepts and representations in order to participate in the learning process and work through a variety of mathematical issues. This article describes how MTs students in South Lampung Regency, using a reciprocal teaching strategy and DMR learning, comprehend ideas and mathematical representations. Using a 2x2 factorial design, the researcher employed the quasi-experimental design research type. MTs students in Central Lampung Regency made up the study's population. A total of 60 students 30 from the experimental class and 30 from the control class—were sampled using cluster random sampling procedures. Essay assessments for conceptual knowledge and mathematical representations served as the data collection tools. Multivariate Analysis of Variant (MANOVA) data analysis with a large significance value ·=5% was used in this study. Based on the calculations that were done, the findings indicate that the p-value for conceptual understanding is 0.000 and the p-value for mathematical representation is 0.000. Since each understanding's p-value is less than 0.05, it can be said that the DMR learning model with reciprocal teaching influences students' conceptual and mathematical representation understanding either simultaneously or in part. For both of the provided learning methods, comprehension of mathematical representations yielded superior results than comprehension of concepts.

Keywords: DMR, reciprocal teaching, concept understanding, Mathematical representation

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Introduction

Since education allows people to reach their full potential, it is the most significant factor in human development (Opoku et al., 2022). This potential encompasses skills, values, knowledge, and attitudes. The way that instruction and learning are carried out in schools has a direct bearing on the quality of education provided. For teachers to be

effective in the classroom and transfer knowledge, learning must be more creative and inventive (Tamsah et al., 2021). As a result of their training in reasoning, students actively reason while they study in class, expanding their comprehension of mathematical ideas (Hunter, 2017).

Thus, it is appropriate to highlight and elevate mathematical representation in the classroom mathematics curriculum. The primary tool for increasing pupils' knowledge and comprehension of mathematical concepts is representation. Adhering to mathematical representation is crucial since it aids in problem solving for kids. Gaining conceptual understanding is one of the main objectives of learning mathematics. The significance of mathematical representation is further supported by Wijaya (2018), who claims that representation is essential to mathematical learning, helping students develop and deepen their understanding of mathematical ideas and the connections between them. Students can use a variety of representations, such as writing, tables, pictures, words, mathematical symbols, and so forth, depending on their level of understanding. Then Huda et al. (2019) also said that representation is a guide for students in understanding and applying mathematical concepts.

Students need to work on and become proficient in two areas: conceptual understanding and mathematical representation. In order for others to understand what they already understand about mathematics, students who already possess this understanding must also be able to represent it. Explaining mathematical ideas to others can improve a student's understanding of the subject. In order to make the application of the learning model captivating and assist instructors' outcomes, a teacher should be astute when choosing the model to be used, taking into account the situations or states of the understudies, learning materials, and sources (Uno & Mohamad, 2022). Learning problems should be overcome in a variety of methods, and the DMR learning model with a reciprocal teaching approach is one of them. Due to its interconnectedness, topics can be better understood by students using the DMR model (Agustina et al., 2019). According to (Rukiyah et al., 2020), the DMR learning model places a strong emphasis on student participation in the process of learning to develop an independent notion in group learning so that students can solve mathematical issues. Using a displaying method in the process of teaching and learning can pique students' curiosity and arouse new appetites; it can also inspire and energize learning activities and have an effect on understudies (Alaban, 2024; Sunarya, 2022; Zannrni & Shareef, 2023). The reciprocal teaching technique trains students' skills in summarizing, detecting what is unclear, asking questions, and publishing to other parties. It gives students the chance to learn more autonomously, creatively, and actively. The ARCS (Attention, Relevance, Confidence, Satisfaction) theory of motivation states that students will be more driven to learn if the material grabs their attention, speaks to their needs, and boosts their self-esteem (Malone & Lepper, 2021; Utomo, 2017).

Several researchers are concerned with the DMR learning model which has been carried out by previous researchers, which has the result that the DMR learning model can improve the ability to understand concepts (Budarsini et al., 2018), improve communication skills and mathematical disposition (Purwasih & Bernad, 2018) improve mathematical representation (Rukiyah et al., 2020), other researchers have also researched the understanding of concepts that can be improved by reciprocal teaching in terms of self-concept (Maulani et al., 2017), by applying the Discovery Learning learning model (Mawaddah & Maryani, 2016), scramble and TTA models (Yuna et al., 2018), Apart from understanding concepts, understanding mathematical

representations has also been researched previously, the results show that mathematical representations can be improved by applying the Problem Based Learning model (Azizah et al., 2019), Novick learning model (Rezeki, 2017), viewed from students' cognitive styles (Tyas et al., 2016),

According to earlier research's findings, the DMR model has been used by numerous researchers; however, no one has used it to examine the impact on MTs pupils in South Lampung Regency's conceptual and mathematical representation comprehension simultaneously and in part. In order to examine the DMR learning model with a reciprocal teaching method to conceptual and mathematical representation understanding, the author performed research.

Research Methods

The information was gathered as numerical data (quantity). It was given the name quantitative research. Quasi Experimental Design is typically employed in this kind of experiment. Posttest Only Control with a 2x2 factorial design is the experimental design that was employed.

Table 1. 2×2 Factorial Design

Learning Model (X)	Researched Abilities (Y)	
	Concept Understanding (Y_1)	**Mathematical Representation (Y_2)**
DMR (Multy Representation Discourse) (A_1)	μ_{11}	μ_{12}
Question and answer model and lecture (A_2)	μ_{21}	μ_{22}

The population of this study included all MTs (Islamic Junior High School) students in the South Lampung Regency, from which a total sample of 60 students was selected using cluster random sampling. This method involved selecting students from existing classes and schools. The sample was divided into two groups: the experimental group, consisting of 30 students who learned using the Multi-Authentic Talk model, and the control group, also consisting of 30 students who followed the explanatory learning method. Data analysis was conducted using MANOVA (Multivariate Analysis of Variance) with a significance level of less than 5%. The data collection process involved administering a seven-question test to assess conceptual understanding and four descriptive questions to evaluate mathematical representation skills, with specific indicators used to measure both competencies.

At the learning stage, research was conducted in each class using the model provided in the flat-sided geometric material (blocks and cubes). Even though it's crucial to understand, especially when it comes to creating data side spaces, this content may be regarded to be one of the ones that students still find challenging (Maisyarah and Prahmana 2020). Following the completion of the material delivery, a post-test is administered to assess conceptual and mathematical representation understanding.

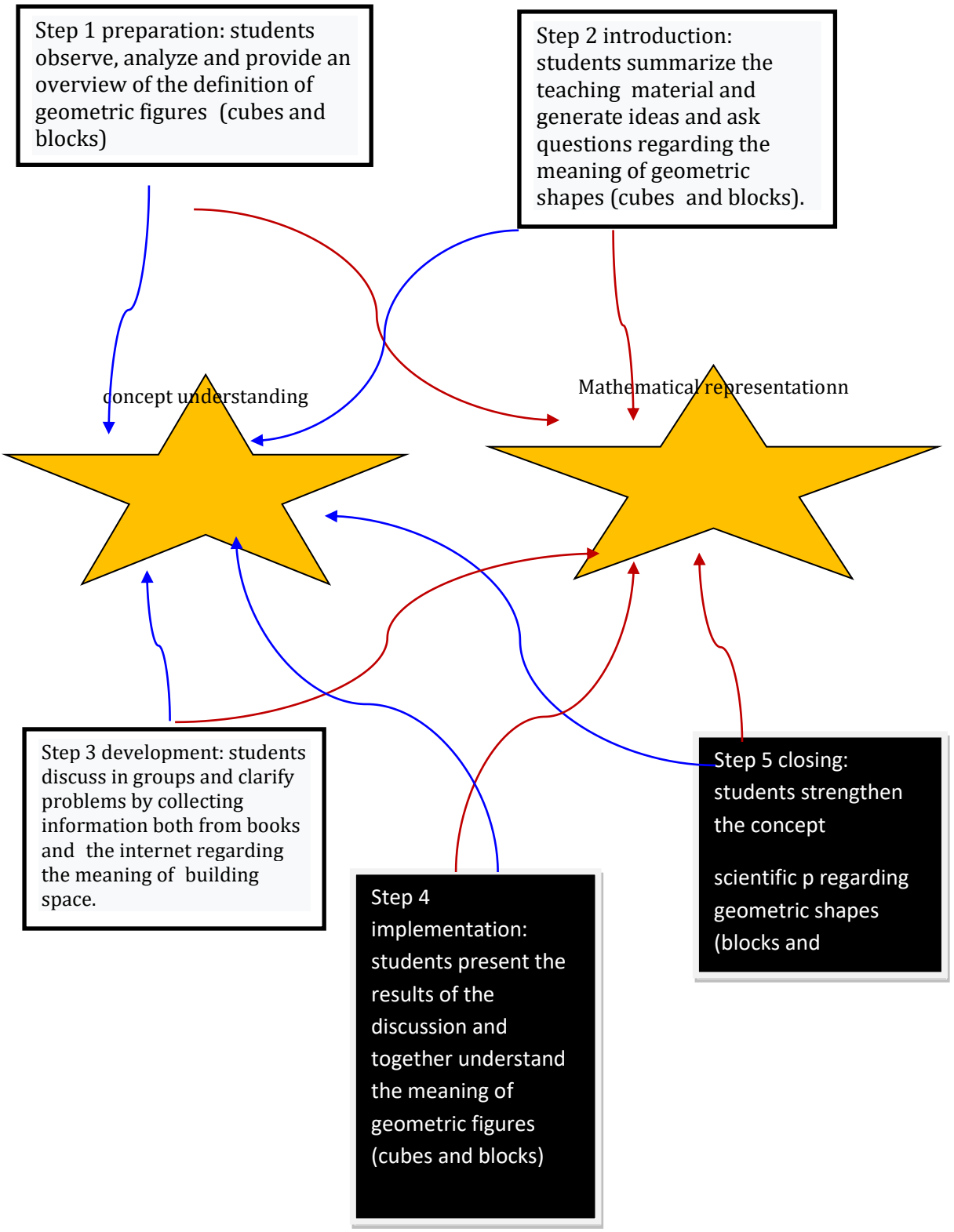
Table 2. Concept Understanding Indicators (Kartika, 2018)

No.	Indicator
1	Restate the concept
2	Classifying objects according to certain properties in accordance with the concept
3	Give examples and non-examples of the concept
4	Presenting concepts in various forms of mathematical representation
5	Developing necessary or sufficient conditions for a concept
6	Using, exploiting and having certain procedures or operations
7	Apply concepts or algorithms to problem solving

Table 3. Mathematical Representation Indicators (Misel & Suwangsih, 2016)

No.	Representation	Operational forms
1	Visuals (diagrams, tables, or graphs)	Create a visual representation (image) of a mathematical problem Converting symbolic representations into visual representations (images) of a mathematical problem.
2	Symbolic	Create symbolic representations to clarify and solve mathematical problems Converting visuals (images) into symbolic representations of a mathematical problem.
3	Verbal (written words/text)	Compose a story that matches the representation presented.

The implementation stages of the Multi Representation Discourse learning model with a reciprocal teaching approach are presented in Picture 1 below.



Picture 1. Syntax of the DMR Learning Model

With a reciprocal teaching strategy, the DMR learning model comprises five stages: preparation, introduction, development, implementation, and close, as seen in Picture 1.

This learning technique may train conceptual comprehension and mathematical representation at each step.

Results and Discussions

Test scores for the experimental class and control group's comprehension of concepts and mathematical representations were gathered based on the research findings. The results indicated that the students taught using the DMR learning model with a reciprocal teaching approach showed a significant improvement in both conceptual understanding and mathematical representation skills compared to the control group. The analysis of test findings is described in Table 3 below.

Table 3. Data Description of Ability to Understand Concepts and Mathematical Representation

Mark	x max	x min	Ability Concept Understanding			x max	x min	Mathematical Representation Ability		
			$\bar{x}$	Std. Dev	N			$\bar{x}$	Std. Dev	N
Experimental Class Post-Test	93	68	78	7.347	30	94	69	81	6.354	30
Control Class Post-Test	82	61	69	8.451	30	88	50	70	10.403	30

From Table 3, we can see that the post-test results of the experimental class were higher than those of the control group. The average score for the ability to understand concepts was 78, and for mathematical representation, it was 81 in the experimental group, compared to 69 and 70, respectively, in the control group. This suggests that the DMR learning model, paired with a reciprocal teaching approach, has a positive effect on students' comprehension of both concepts and mathematical representations.

Before performing the Multivariate Analysis of Variants (MANOVA), normality and homogeneity tests were conducted. The normality test results are shown in Table 4 below.

Table 4. Normality Test Results

Variable	Experimental Class	Control Class	Conclusion
Concept Understanding Ability	0.165	0.200	Normally distributed
Mathematical Representation Ability	0.080	0.200	

As seen in Table 4, the test data for both conceptual understanding and mathematical representation were found to be normally distributed in both groups. The next step was to assess the homogeneity of the data, as shown in Table 5.

Table 5. Homogeneity Test Results

Variable	Sig.	Conclusion
Concept Understanding Ability	0.714	Homogeneous
Mathematical Representation Ability	0.281	

The data presented in Table 5 demonstrate that the statistics for both conceptual understanding and mathematical representation abilities are homogeneous, indicating that the variance between the experimental and control groups is consistent.

Following these preliminary tests, hypothesis testing was conducted using MANOVA. The simultaneous test results for both variables are presented in Table 6.

Table 6. Simultaneous MANOVA Test Results

MANOVA Hypothesis		Sig.	Conclusion
DMR model with a reciprocal teaching approach	Wilks' Lambda	0.000	H0 is rejected

According to Table 6, the MANOVA test using Wilks' Lambda returned a p-value of 0.000, which is below the significance threshold of 0.05. This means that the DMR learning model with a reciprocal teaching approach has a statistically significant effect on students' ability to understand mathematical concepts and representations.

The next step was to analyze the partial effects of the independent variables on each dependent variable separately. The results are shown in Table 7.

Table 7. Partial MANOVA Test Results

Category	Ability	Sig.	Conclusion
DMR model with a reciprocal teaching approach	Concept Understanding	0.000	H0 is rejected
	Mathematical Representation	0.000	H0 is rejected

From Table 7, we can see that both conceptual understanding and mathematical representation skills are significantly influenced by the DMR learning model with a reciprocal teaching approach, as indicated by p-values below 0.05.

Discussion

The analysis results show a clear positive impact of the DMR learning model combined with a reciprocal teaching approach on both conceptual understanding and mathematical representation abilities. However, a deeper exploration is needed to explain why this model was effective in improving these skills.

DMR Learning Model and Reciprocal Teaching Approach

The DMR (Discovery, Modeling, and Reflection) learning model encourages active learning and collaboration among students. It promotes problem-solving, critical thinking, and active participation in learning processes, which are essential for building both conceptual understanding and mathematical representation. The DMR model follows three main phases: (1) Discovery: Students explore problems and seek solutions independently or in groups; (2) Modeling: Students are provided with examples and models of the mathematical concepts being taught, and (3) Reflection: Students reflect on the process and outcomes, consolidating their understanding of the concepts.

The reciprocal teaching approach adds layer by fostering student-teacher and peer interaction (Downer et al., 2010; Wilkinson et al., 2002; Youens et al., 2014). In this approach, students take turns leading discussions, summarizing information, and asking questions, which enhances their engagement and ensures that they process information at a deeper level.

Why the DMR Model and Reciprocal Teaching Improve Conceptual Understanding

The DMR model's emphasis on discovery and reflection provides students with the autonomy to construct their own understanding of mathematical concepts, rather than relying solely on teacher instruction. The reciprocal teaching aspect further deepens this understanding by promoting active participation and peer explanation (Lewthwaite & Nind, 2016; Pressick-Kilborn & te Riele, 2008; Schünemann et al., 2013). As students engage in these activities, they are required to internalize and communicate concepts, leading to better retention and comprehension.

Impact on Mathematical Representation

Mathematical representation is inherently linked to the ability to communicate mathematical ideas using symbols, diagrams, and equations. The reciprocal teaching method, which emphasizes questioning, summarizing, and explaining, naturally lends itself to developing these skills. The DMR model's phase of modeling also provides students with explicit representations, which they can then apply in problem-solving scenarios (Adnyana et al., 2021; Chusni, 2023; Gilchrist et al., 2021; Phillips et al., 2023; Qin et al., 2024).

Magnitude of Influence

The findings show that the DMR learning model with a reciprocal teaching approach has a high impact on both conceptual understanding and mathematical representation. However, the impact appears to be slightly greater on mathematical representation, as indicated by the higher average scores for representation (81) compared to concept understanding (78) in the experimental group. This could be due

to the DMR model's focus on modeling, which directly enhances students' ability to visualize and represent mathematical problems (Medina Herrera et al., 2024; Singh & Azman, 2023).

In conclusion, the combination of the DMR model and reciprocal teaching creates a learning environment where students not only understand mathematical concepts but are also able to represent them effectively. The logical cause-effect relationship is supported by both the theoretical foundation of active learning and the statistical evidence from the data (Andreou et al., 2014; Cheng & Khoo, 2021; Frye & Hemmer, 2012; Grace et al., 2012; Jeram, 2024; Seal, 2022).

Conclusions and Suggestions

This study concludes that the DMR learning model combined with a reciprocal teaching approach significantly enhances students' conceptual understanding and mathematical representation abilities. The experimental group outperformed the control group, with statistical analysis confirming the effectiveness of this method. Notably, the reciprocal teaching approach had a greater impact on improving mathematical representation, possibly due to its focus on modeling during problem-solving activities. It is recommended that this approach be widely implemented in mathematics education, with proper teacher training to ensure its effective use. Further research should explore its long-term effects and potential applications in other subjects. Tailoring instruction to balance students' conceptual and representational skills will ensure a more comprehensive learning experience.

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